

WHAT IS CLAIMED IS:

1. An ink delivery device for direct-write nanolithographic printing of inks with use of a tip or tip array comprising:

ink reservoirs,

microfluidic channels connected to the ink reservoirs;

dipping wells connected to the microfluidic channels,

wherein the dipping wells have a geometry for dipping the tip or tip array into the dipping wells.

2. The ink delivery device according to claim 1, wherein the dipping wells have a geometry such that evaporation of the ink is minimized.

3. The ink delivery device according to claim 1, wherein the microfluidic channels have a geometry such that evaporation of the ink is minimized.

4. The ink delivery device according to claim 1, wherein the ink reservoirs have a geometry such that evaporation of the ink is minimized.

5. The ink delivery device according to claim 1, wherein the dipping wells, the microfluidic channels, and the ink reservoirs have a geometry such that evaporation of the ink is minimized.

6. The ink delivery device according to claim 1, wherein the surface chemistry of the wells and channels, or their surrounding areas, is modified to guide ink to precise locations.

7. The ink delivery device according to claim 5, wherein the surface chemistry is modified with a hydrophilic modification or a hydrophobic modification.

8. The ink delivery device according to claim 1, wherein the device further includes integrated microelectronics.

9. The ink delivery device according to claim 1, wherein the device further includes alignment marks.
10. The ink delivery device according to claim 1, wherein the device further includes posts.
11. The ink delivery device according to claim 1, wherein the microfluidic channels are open channels.
12. The ink delivery device according to claim 1, wherein the microfluidic channels are closed channels.
13. The ink delivery device according to claim 1, wherein the wells are micromachined wells.
14. The ink delivery device according to claim 1, wherein the microfluidic channels become more narrow with the flow of ink to the wells.
15. The ink delivery device according to claim 1, wherein reservoir, channels, and wells are disposed on a silicon wafer.
16. The ink delivery device according to claim 1, wherein the wells or channels are filled with a filler.
17. The ink delivery device according to claim 1, wherein the wells or channels are filled with a filler capable of retaining ink with minimum evaporation.
18. The ink delivery device according to claim 1, further comprising micromechanical pumps and microvalves.
19. The ink delivery device according to claim 1, wherein the tip is a scanning probe microscopic tip and the tip array is an array of scanning probe microscopic tips.

20. The ink delivery device according to claim 1, wherein the tip is an atomic force microscopic tip and the tip array is an array of atomic force microscopic tips.
21. The ink delivery device according to claim 1, wherein the spacing of the dipping wells provides reduction in cross contamination.
22. The ink delivery device according to claim 1, wherein the size of the dipping wells helps prevent wicking.
23. The ink delivery device according to claim 1, wherein the size of the dipping wells allows the tip and tip array to be dipped into the dipping wells.
24. The ink delivery device according to claim 1, wherein the size of the dipping wells helps prevent wicking, and the size of the dipping wells allows the tip and tip array to be dipped into the dipping wells.
25. The ink delivery device according to claim 1, further comprising a syringe.
26. The ink delivery device according to claim 1, wherein the microfluidic channels are open channels, wherein the device further includes alignment marks, and wherein the dipping wells, the ink reservoirs, and the microfluidic channels have a geometry such that evaporation of the ink is minimized.
27. The ink delivery device according to claim 26, wherein the tip is an atomic force microscopic tip and the tip array is an array of atomic force microscopic tips.
28. The ink delivery device according to claim 27, further comprising a syringe.
29. A delivery device for direct-write nanolithographic printing using a tip array comprising:
 - reservoirs,
 - microfluidic channels connected to the reservoirs;
 - an array of dipping wells connected to the microfluidic channels,

wherein the array of dipping wells has a geometry which matches the arrangement of the tip array.

30. The delivery device according to claim 29, wherein the tip array is an array of atomic force microscope tips and the device further comprises alignment marks.

31. A method of creating an array of inked probes for performing direct-write nanolithographic printing, the method comprising the steps of:

(a) providing an array of wells, channels, or posts, wherein at least some of the wells, channels, or posts have an ink therein;

(b) providing an array of tips, wherein the tips are adapted to be associated and aligned with said wells, channels, or posts;

(c) transferring ink in at least some of the wells, channels, or posts having ink therein onto the tips or probes associated therewith by:

(c1) immersing the tips or probes in the wells or channels associated therewith; or

(c2) contacting the tips or probes with the posts associated therewith.

32. The method according to claim 31, wherein the number of tips and the number of wells, channels, or posts is the same.

33. The method according to claim 31, wherein the number of tips is less than the number of wells, channels, or posts.

34. The method according to claim 31, further comprising the step of:

controlling the surface chemistry of each of the wells, channels, or posts, and/or controlling the surface chemistry of surrounding areas which surround the wells, channels, or posts.

35. The method according to claim 34, wherein the step of controlling the surface chemistry of each of the wells, channels, or posts comprises:

controlling the hydrophilicity or hydrophobicity of the wells, channels, or posts; and/or

controlling the hydrophilicity or hydrophobicity of the surrounding areas.

36. The method according to claim 34, wherein the step of controlling the surface chemistry of each of the wells, channels, or posts is selected from the following group:

- (a) coating the wells, channels, posts or the surrounding areas with a thin film,
- (b) coating the wells, channels, posts or the surrounding areas with a self-assembled monolayer,
- (c) coating the wells, channels, posts or the surrounding areas with a fluorinated polymer material,
- (d) coating the wells, channels, posts or the surrounding areas with polyimide, wherein the polyimide is spin-on and patterned by: (1) depositing a thick photoresist or metal film, (2) creating a window in the photoresist or metal film; and (3) treating with oxygen plasma,
- (e) coating the wells, channels, posts or the surrounding areas with a thermal, plasma-enhanced or low temperature deposited oxide,
- (f) coating the wells, channels, posts or the surrounding areas with silicon nitride, a metal or metal oxide, and
- (g) plasma treating the wells, channels, posts or the surrounding areas through a patterned resist.

37. The method according to claim 34, wherein the step of controlling the surface chemistry of each of the wells, channels, or posts is by chemical treatment with oxidizer.

38. The method according to claim 31, wherein the ink provided in at least some wells, channels, or posts is provided by an external device.

39. The method according to claim 38, wherein the external device is selected from the group consisting of an inkjet print head, a pipette, pin-and-ring or microcapillary micro spotter system.

40. The method according to claim 38, wherein the external device is a syringe.

41. The method according to claim 38, wherein the external device is a microsyringe on an x-y-z stage.

42. The method according to claim 31, wherein the ink provided in at least some wells, channels, or posts is continuously provided by an integrated microfluidic network.

43. The method according to claim 42, wherein the microfluidic network comprises a set of microfabricated reservoirs connected via microscopic channels to at least some wells, channels, or posts.

44. A system comprising:

an array of probes;

at least one ink source having an ink therein;

a microfluidic delivery system adapted to carry said ink to said array of probes;

device for transferring the ink onto selected probes; and

a substrate adapted to be contacted by said array of probes, and wherein when the array of probes is in contact with the substrate, those probes having ink thereon will deposit the ink onto the substrate.

45. The system according to claim 44, wherein the ink source is a reservoir.

46. The system according to claim 44, further comprising:

an environmental control system.

47. The system according to claim 44, further comprising:

an alignment mechanism adapted to align the probes with the device for transferring the ink onto the selected ones of said probes.

48. The system according to claim 44, wherein solid-phase synthetic methods are applied to the probe surface to generate ink on the probe surface.

49. The system according to claim 44, wherein the device for transferring ink comprises an inkjet nozzle.

50. The system according to claim 44, wherein the device for transferring the ink onto the selected ones of said probes provides for dipping said selected ones of said probes in at least one reservoir containing the ink.

51. A substrate comprising:
an array of wells and channels,
wherein the wells and channels are adapted to be associated and aligned with an array of tips for direct-write nanolithographic printing of ink on the tips.

52. The substrate according to claim 51, wherein the wells or channels are at least partially filled with a filler.

53. The substrate according to claim 51, wherein the wells or channels are at least partially filled with a spongy or porous filler which is adapted to retain ink in the wells or channels while limiting ink evaporation.

54. The substrate according to claim 51, wherein the wells or channels are separated from each other in all dimension by a distance which is less than about 200 microns and which is greater than about 1 micron.

55. The substrate according to claim 51, wherein the surface chemistry of the wells and channels, or of their surrounding area, is manipulated to guide an ink in precise locations of the array.

56. The substrate according to claim 51, wherein the surface chemistry is manipulated by modification of hydrophilicity or hydrophobicity.

57. The substrate according to claim 51, wherein the channels are open channels.

58. The substrate according to claim 51, wherein the channels are closed channels.

59. The substrate according to claim 51, wherein the substrate further comprises reservoirs.

60. The substrate according to claim 51, wherein the substrate further comprises reservoirs in the path of the microchannels to function as bubble traps.

61. An ink delivery device comprising a probe holding device for direct-write nanolithographic printing of inks with tips, wherein the device is integrated directly with microfluidic circuitry for delivery of ink to the probe.

62. The ink delivery device according to claim 61, wherein the device further comprises ink reservoirs and microfluidic channels.

63. The ink delivery device according to claim 61, wherein the device further comprising reservoirs in the microfluidic channels for preventing bubble formation.

64. The ink delivery device according to claim 62, wherein the microfluidic channels are associated with microactuators, valves, and microelectronic circuitry.

65. The ink delivery device according to claim 61, wherein the device is attached to a fluid management system.

66. The ink delivery device according to claim 61, further comprising a syringe.

67. The ink delivery device according to claim 61, further comprising a microsyringe on an x-y-z stage.

68. The ink delivery device according to claim 61, wherein the device further comprises an environmental control enclosure.

69. The ink delivery device according to claim 61, wherein the device further comprises an alignment device for alignment with an ink source.

70. The ink delivery device according to claim 70, wherein the alignment device comprises a digital imaging apparatus.

71. A microfluidic device comprising:
- a substrate comprising a surface and a plurality of microchannels which are hydrophilically surface treated, and
- at least one hydrophobic barrier layer on the surface between the microchannels which prevents cross contamination between the plurality of microchannels when liquid flows through the microchannels.
72. The microfluidic device according to claim 71, wherein the hydrophobic barrier layer is a polymeric layer.
73. The microfluidic device according to claim 71, wherein the hydrophobic barrier layer is a fluorinated polymeric layer.
74. The microfluidic device according to claim 71, wherein the hydrophobic barrier layer is produced by a plasma.
75. The microfluidic device according to claim 71, wherein the hydrophobic barrier layer is produced by a plasma with use of a deep reactive ion etching instrument.
76. The microfluidic device according to claim 71, wherein the microchannels are configured to deliver liquid ink to or from one or more reservoirs and are adapted for use in transferring the ink to a nanolithography tip as an inkwell.
77. The microfluidic device according to claim 71, wherein the device is an ink well for use in nanolithography and further includes alignment marks.
78. The microfluidic device according to claim 71, wherein the hydrophobic layer is about 10 microns thick or less.
79. The microfluidic device according to claim 71, wherein the hydrophobic layer is about one micron thick or less.
80. The microfluidic device according to claim 71, wherein the hydrophobic layer comprises at least one monolayer.

81. A microfluidic device comprising:
a substrate comprising a surface and a plurality of microchannels, and
at least one hydrophilic barrier layer on the surface between the microchannels
which prevents cross contamination between the plurality of microchannels when liquid
flows through the microchannels.
82. The microfluidic device according to claim 81, wherein the microchannels are
configured to deliver liquid ink to or from one or more reservoirs and are adapted for use
in transferring the ink to a nanolithography tip as an inkwell.
83. The microfluidic device according to claim 81, wherein the device is an ink
well for use in nanolithography and further includes alignment marks.
84. The microfluidic device according to claim 81, wherein the hydrophilic layer
is about 10 microns thick or less.
85. The microfluidic device according to claim 81, wherein the hydrophilic layer
is about one micron thick or less.
86. The microfluidic device according to claim 81, wherein the microchannels are
hydrophobic.
87. A microfluidic device comprising:
a substrate comprising a surface and a plurality of microchannels, wherein an ink
has a contact angle of less than 90 degrees on the microchannel surface, and
at least one barrier layer on the surface between the microchannels, wherein the
ink has a contact angle of more than 90 degrees with the barrier layer.
88. A microfluidic device comprising:
a substrate comprising a surface and a plurality of microchannels which are
hydrophilically surface treated, and

at least one hydrophobic barrier layer on the surface between the microchannels which prevents cross contamination between the plurality of microchannels when liquid flows through the microchannels.

89. An inkwell device adapted for use for dipping of a nanoscopic tip to transfer ink from the inkwell device to the tip, wherein the inkwell device comprises at least one hydrophobic barrier layer on a substrate surface which prevents ink from travelling out of a microchannel disposed next to the hydrophobic barrier layer.

90. The inkwell device according to claim 89, wherein the device further comprises alignment marks and ink reservoirs with microchannels radiating from the reservoirs.

91. A method for keeping liquid inside a microchannel as it flows through the microchannel and prevent cross contamination comprising the steps of :

providing a patterned photoresist on a substrate,
etching the substrate to form a microchannel,
removing photoresist, and
deposition of hydrophobic barrier layer on the substrate surrounding the microchannel.

92. A method for keeping liquid inside a microchannel as it flows through the microchannel comprising the steps of:

(A) providing a patterned photoresist on a substrate, wherein the substrate comprises an underlying substrate layer and an oxidized overlayer which contacts the photoresist,
(B) etching of the oxidized overlayer,
(C) removing the photoresist, and
(D) depositing of hydrophobic barrier layer on the substrate surrounding the microchannel.

93. A method for keeping liquid inside a microchannel as it flows through the microchannel and prevent cross contamination comprising the steps of :

deposit a hydrophobic barrier layer onto a substrate,

pattern a photoresist onto the hydrophobic barrier layer,
etch microchannels into the substrate, and
remove the photoresist.

94. The method according to claim 93, further comprising etching of at least one reservoir and at least one inkwell.

95. A method for preventing cross contamination in closely spaced microchannels in a microfluidic device comprising the step of forming a hydrophobic barrier layer between the microchannels, wherein the hydrophobic layer is disposed on the substrate surface surrounding the microchannels.

96. A method of fabricating an inkwell device comprising etching microchannels into a substrate, and depositing a hydrophobic barrier layer on surfaces next to the microchannels, wherein the same instrument is used for both the etching step and the depositing of the hydrophobic barrier layer.